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THE HUMAN FACTOR IN PLANT GENETIC RESOURCES CONSERVATION

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ABSTRACT

Expansion of or establishment of plant genetic resources (PGR) programs by national and international agricultural research centers during the past two decades, coupled with vastly expanded field collection activities, has markedly increased the world's PGR collections. However, genetic erosion in farmer's fields, natural habitats and inside genebanks also continued at alarming rates.

A crucial component in conservation efficacy is the human factor: the quantity and quality of PGR workers. Many workers are inadequately trained or poorly prepared to accept the tedium, heavy load, multifaceted assignments, and low recognition related to their tasks. Their mission generally receives poor support from the administration.

As remedial measures, training programs of various formats need to be redevised and expanded to develop more competent workers for this young and growing technology. The morale of PGR workers needs to be boosted. The workers themselves also need to strive for greater interdisciplinary roles and improved service spirit so as to become more effective partners in the expanded crop improvement projects involving biotechnological approaches. Another crucial measure hinges on greater inter-institutional and international collaboration in fully using available resources. Schemes of collaboration are proposed.

Plant growers, whether farmers or home gardeners, should be enrolled to participate in conservation efforts. The public sector of human society should be better informed on PGR conservation so as to secure enhanced and sustained support for the necessary activities.

INTRODUCTION

During the past two decades the world has witnessed a keen awareness of the importance of plant genetic resources (PGR) and the need to conserve biological diversity. In the scientific community the recognition of dwindling biological resources in nature was intensified by the forays of scientific teams into little traveled areas where serious genetic erosion has occurred. Awareness of the general public was hightened by the growing concern for the quality of the human ecosystem. Reports of the mass media about the strife centering on germplasm ownership control and the use of this vanishing resources magnified the heated debates in the FAO sessions in the late 1980s. Greatly publicized controversies on the rights of use aroused by socio-political activists have thus helped to direct public attention to PGR which remained an adjunct to plant breeding until the late 1960s (Chang, 1985a: Frankel, 1985-87; National Research Council, 1993).

The merging forces led to greatly expanded and accelerated conservation activities in the 1970s and lasting through the 1980s, largely in field collection operations and the establishment of PGR centers (genebanks) by national and international institutions. Of these, the International Agricultural Research Centers (IARCs) under the Consultative Group on International Agricultural Research system, notably the International Board for Plant Genetic Resources (IBPGR) established in 1974, have played a leading role in collecting, preservation, dissemination and use of crop germplasm. Success of the IARCs has stimulated many national agricultural research systems to initiate or expand such activities. By the mid-1980s, the total holdings of the world's genebanks grew to 2.5 million accessions, of which a little over one million may be considered distinct or unduplicated in another genebank (see Chang, 1992). However, genetic erosion, both in the field and inside genebanks, also occurred at an alarming pace (see Chang et al, 1979; Goodman, 1984; Harlan, 1984; Fowler et al., 1988), though the exact statistics are not available. It is also open to question as to how many conserved accessions are viable and available for use.

Genetic conservation of plants is exclusively a human activity which dated back to the beginning of agriculture when humans extended help in plant propagation and perpetuation. Plants also need human inputs in the preservation of their genetic integrity and diversity. It was a mistaken notion of many people that plants can "take care" of themselves, while biodiversity has been on the decline since modern agriculture began. Nowadays even the

wild relatives of rice need human care (Vaughan and Chang, 1992). It has been pointed out that PGR conservation is a young technology and yet to be fully developed (Chang, 1985a). On the other hand, it is a labor intensive, complex, painstaking activity, requiring the inputs of diverse disciplines and professions. The lack of well trained workers was keenly felt when field collecting activities were greatly expanded in the late 1970s and much of the acquired germplasm materials awaited proper processing and preservation.

The paper aims to discuss the human factor in PGR conservation: its crucial role in the overall program, the constraints, the needs in human resource development, and future directions. These aspects are vital to enhancing the efficacy and sustainability of PGR conservation programs.

RECENT GROWTH IN PGR CONSERVATION PROGRAMS: PHYSICAL ASPECTS

In addition to the active field collecting activities of the past two decades, encouraging signs in the global expansion of PGR programs are indicated by two developments: establishment of national PGR centers and the construction of modern genebank facilities. The most significant developments came from two large and germplasm-rich countries: India and mainland China. In India, the former Division of Plant Introduction in the Indian Agricultural Research Institute was reorganized and expanded into the National Bureau of Plant Genetic Resources in 1976. A modern genebank is nearly completed with assistance from the USAID and several regional stations are being improved with aid from the UK. On the China mainland, a new Institute of Crop Germplasm Resources was established in 1978 and two large refrigerated seed storage facilities were built in the 1980s. The second one having long-term storage facility and laboratory complex was built with assistance from the Rockefeller Foundation.

During the same period, several IARCs built or upgraded their genebank facilities. In Southeast Asia, modern genebanks were added in Thailand, Philippines, Sri Lanka, Burma, Nepal and Kampuchea, often with funds and equipment from Japan. Japan and the USA added new structures to their national genebanks, while the R.O. Korea built a new facility. The National Plant Genetic Resources Center in R.O. China on Taiwan is one of the latest additions.

The marked growth in genebanks with medium-term and/or long-term storage facilities, esp. in the developing world, is shown below (Pluckneet et al., 1983; Chang, 1992).

Category	No. in mid 1970s	No. in 1991
Developed countries	16	25
Regional bank in a developed country	1	1
Developing countries	3	30
Regional genebanks in devloping countries	1	2
IARCs in developing countries	4	9

While the less fortunate PGR centers without the cold rooms in the developing world are faced with the most serious challenge in the need for frequent seed rejuvenation, many modern genebanks in the developing countries are also stressed by huge electricity bills, lack of spare parts and lack of local expertise in refrigeration technology/repairs.

CONSTRAINTS IN PGR CONSERVATION PROGRAMS

While every PGR center tends to boast on the recent growth in germplasm holdings, nearly all centers share the following constraints (see Goodman, 1984; Anon., 1987; Peeters and Williams, 1984; Chang, 1985b; Williams, 1989; Engle and Chang, 1991) :

(1) Insufficient technical staff and supporting service crew--the staff is often skeletal.

(2) Inadequate planting, processing and storage facilities and substandard practices. Field regeneration and seed processing following the acquisition of a modern storage facility presents a crushing work load.

(3) Under-funded and/or unstable support from the authorities above.

(4) Huge backlog of germplasm materials to be regenerated, processed and stored; equally bulky records to be entered in computerized data management systems.

(5) Heavy work load related to requests for seed/information, while the service role receives little credit in crop improvement.

(6) Poor communication/coordination with affiliates in crop improve-

ment, resulting in inadequate evaluation and under use of conserved germplasm.

(7)Inadequate *ex situ* preservation and viability monitoring methods for certain crops and little *in situ* conservation for many crops.

These constraints inevitably lead to continuing erosion within the plant collections and affect the long-term security of the conserved stocks. Restricted dissemination of germplasm materials and related information have impaired multidisciplinary evaluation and research, resulting in a low use of the vast resources for productive purposes (see Chang, 1985c, d, 1991a, 1992; Marshall, 1989).

DIMENSIONS OF THE HUMAN FACTOR

As stated earlier, PGR conservation is based on human inputs. In the long and myriad-faceted process of conservation, the PGR workers face a complicated series of operations: field collecting , multiplication or regeneration, characterization of preliminary evaluation, preservation, dissemination, data management, and, more recently, germplasm enhancement and informing the public. Much of the expertise in dealing with diverse plant species requires technical knowledge and experience that are species-, location and growth stage-specific, stemming from one's inherent interest and intuition--often missing in published work. It takes long years for a dedicated worker to develop into an effective PGR specialist. Continuity of personnel in key operations is also a critical factor in ensuring the effectiveness of genebank operations (see Chang et al., 1989). It is unfortunate that the crucial role of PGR workers in promoting the security and use of germplasm collections was often overlooked by the decision-makers. They can play a central role in overcoming the existing constraints in PGR programs (Chang, 1987; Chang et al., 1989).

While we recognize the crucial role of the PGR workers, what are the common constraints? As common to most new frontiers of research and technology, both quantity and quality are the principal problems. This matter in PGR conservation is compounded by the lack of institutions/programs that can provide the appropriate training to a large number of trainees/students over a diverse array of specialized subjects on a sustained basis. Agricultrual colleges, with the exception of the Applied Biology Department in University of Birmingham, offer no more than a single semester course each in PGR and seed physiology. Professor J. G. Hawkes and associates at Birmingham

initiated the MS and PhD courese in 1975 with substantial aid from the IBPGR, but the training site has no agricultural experiment station or a genebank. A number of short courses, largely supported by the IBPGR and devoted to field collection, have been helpful in developing field collectors, but they later confronted the equally challenging task of multiplication, characterization, storage and dissemination which they were poorly prepared. We at the International Rice Research Institute (IRRI) have held training courese (4-6 months at IRRT, plus collecting in home country) that combined the teaching of principles and hands-on practices, but such courses are costly and confined to the rice crop. Other IARCs have also held similar courses with shorter durations. Other international courses dealt with data management, *in vitro* techniques and clonal genebank management. The University of California has conducted two short courses (4-5 weeks) of international scope which provided an overview of PGR activities, but again the costs were high.

Over the years with IBPGR funding, more than 200 students have received graduate training and over 500 trainees attended short courses (Williams, 1984; Hawkes, 1985), but the numbers lagged behind the actual needs. It is also problematic to continue various training programs in the face of dwindling financial resources.

In my extensive visits to national PGR centers, I found out that a large number of the college graduates who became PGR officers took the positions not out of their own interest but because other preferred jobs (frequently plant breeding) were not available to them. A substantial number of the workers did not stay long on PGR work. Those who stayed on often complained of excessive work load without supporting labor force, meagre opportunity to conduct publishable research projects, and little help or encouragement from the officers above.

They felt isolated and left out of the main stream of research or breeding. As a service sector, their contributions to crop improvement were rarely recognized. As a result, the morale was generally lower than expected.

It is a more daunting challenge to serve as a genbank manager (curator) who has to cope with numerous problems, esp. the high power bills and uncooperative refrigeration technicians. In day-to-day work, he has to deal with the harried needs of an under-supported technical staff. Coordinating the time-restricted field work with lab. processing and storage is particularly challenging. Few managers stayed long on their posts in the developing world.

In my meetings with fellow workers and in my recent writings, I have urged the PGR workers to fully exert their expertise and service capability

in helping other crop scientists on various research fronts that involve novel germplasm. With good service comes the respect of the users. Meanwhile, I exhort them to be more active and aggressive in offering their materials and knowledge so as to become a full partner in interdisciplinary evaluation, research and germplasm enhancement. The more senior workers are urged to share their expertise with newcomers as a part of the on-the-job training. A PGR worker should also devote time to educate other sectors of society on the importance of germplasm. However, assistance and collaboration from colleagues in other disciplines and the plant growers in the field are also essential (Chang, 1985c, 1991a, 1992). Assistance and collaboration from the private seed industry toward a freer exchange of germplasm would also help the overall conservation efforts.

Outside the scientific community, the growers of plants, whether farmers or home gardeners, are often overlooked as powerful coworkers in field conservation. The farmers are crucial to the success of *in situ* conservation of primitive cultivars (land races) and traditional types of fruit tress, vegetables and floral species. Their collaboration should be sought by national PGR systems. Even the school teachers and children can play a part: in northern Thailand the schools make an annual planting of traditional upland (dryland) rice varieties as a part of the teching practice and help in perpetuating the colorful and diverse rices (Vaughan and Chang, 1992).

Seed Saver's Exchange and similar community groups in the US have served an effective role in conserving old vegetable and floral cultivars (see RAFI, 1986; Fowler and Mooney, 1990). Voluntary activities of the NGOs are taken on new significance as governmental actions cannot catch up with events outside experiment stations.

NEEDS IN HUMAN RESOURCE DEVELOPMENT

Since effective PGR workers are a rare breed, let us ask the question: what are the requisites? First, the person has to be a naturalist who cares about plants and other components in the ecosystem. The major subject in college education can be in any field of plant science: genetics, breeding, physiology, taxonomy, pathology, plant propagation. The new worker must have the inner drive to learn about and experiment with the plants under his /her charge in order to become an expert on the plant(s) and the adapted environments. Team work and the spirit to serve others are also essential. Above all, a dedication to conserve plants and to expand their usefulness is the mission of a promising newcomer.

A PGR worker must deal with large numbers, be it collected samples or field plots. Prior exposure to plant breeding practices will come in handy. Facility with computer equipment and software programs is indispensable. A strong background in classical botany will be equally helpful as familiarity with biochemical-microbial techniques.

During the two training courses on rice germplasm conservation held at IRRI, we noted that the workers from developing nations were so used to work in isolation that they were initially uneasy about our practice of placing them in pairs during field or lab exercises. While most of the trainees soon became used to this novel mode of operation, a few preferred to work alone. The trainees were impressed by the open door format of our Germplasm Center where any user can have access to the open databooks and ask for seed or information. They witnessed our "Service is our motto" in action. They were also exposed to our tradition in which a worker would voluntarily fill in for another when the worker in charge was absent. Perhaps such exposures will benefit the trainees more in their later career than the massive technical details that the mentors tried to force feed them in a short course. The contact with workers in other national program would undoubtedly enhance germplasm exchange and collaboration following their return to home countries.

On-the-job training and supplementary short courses should form a continuing component of staff upgrading. In my experience, the most capable workers came from student-assistants who began to work for the Center in their junior years. Early training and careful screening are imperative in developing effective PGR workers because the assignments require infinite patience, vigilance and accuracy.

To help the managers, I have prepared a chapter on genebank management that discussed current issues in management (Chang, 1991b, c) in relation to some of the problems encountered by national workers in rice genebanks (Engle and Chang, 1991). For many PGR centers, successors should be recruited in advance and nurtured in a staff development program (Chang et al., 1989).

FUTURE ENDEAVORS

In looking forward into the twenty-first century, the world will need more and better PGR workers who will care for the preciously fewer plants and to fully exploit their potentials. Their collaborators will extend beyond plant breeders and biotechnologists to include workers in animal science and

forestry. Their service spirit and cooperative attitude will count as much as scientific expertise. We must prepare for the attrition in number due to the tedious and unglamorous nature of the work.

In the face of dwindling resources on a world-wide scale nations, institutions, disciplines and various sectors of society must pool and share their available resources in implementing and ever-growing array of operations that are a part of the food chain in feeding the burgeoning populace. PGR will continue to serve as the hub of all plant research improvement activities. Full collaboration between highly industrialized, germplasm -poor nations and the less developed, germplasm-rich nations is particularly curcial.

I have expanded on a previous scheme to extend the collaboration on germplasm conservation, research, enhancement and use as follows.

Less developed countries serving as:	Developed countries serving as:
sources of genetic diversity and germplasm materials	sources of funding and sophisticated research
site for seed rejuvenation in home environment	*ex situ* preservation and distribution sites
site of *in situ* conservation field research sites	purification and disease elimination of stocks
	genebank training centers

Moreover, the IARCs should continue to serve as essential links in international activities. The private seed industry should also contribute funds to the conservation efforts from which it has been a beneficiary. Public support to conservation efforts and international germplasm exchange will be boosted by improved information and communication programs.

Within one country, different research and educational institutions should also pool resources and collaborate on PGR training. As a case example, the National Seed Storage Laboratory of the US was urged to serve as a training center for PGR workers in the National Plant Germplasm System and from abroad (National Research Council, 1988). The National Plant Genetic Resources Center of R.O. China is also expected to play such a role in the future .

It is my conviction that the future generations of mankind will continue

to benefit from the caring, pooling and sharing of plant genetic resources only when they collaborate and coordinate their inputs.

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